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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

DIVISIONAL APPLICATION (37 CFR 1.53(b))

Docket No. OT-4190B  
Anticipated Class Sub  
Prior Application  
Art Unit: 3652  
Examiner: T. Tran

jc871 U.S. PTO  
09/57558  
05/24/00

Director of Patents and Trademarks  
Washington DC 20231  
Box: Div. Application

Sir:

This is a request for filing a Divisional Application under 37 CFR 1.53(b) of prior pending application Serial No. 09/031,108 on February 26, 1998.

Inventor(s): Pedro S. Baranda, Ary O. Mello, Hugh J. O'Donnell and Karl M. Prewo

Title: Tension Member for An Elevator

1. Enclosed is a copy of the prior pending application, including the declaration, as originally filed.
2. Filing Fee calculation for claims as filed less any cancelled below:

	Number Filed	Number Extra	Rate	Basic Fee	\$690
Total Claims	[ 14 ] - 20 = 0	[ ] x	\$ 18 =		-0-
Independent Claims	[ 1 ] - 3 = 0	[ ] x	\$ 78 =		-0-
Multiple Dependent Claims			\$260 =		-0-
			Total Fee		\$690

3. Please charge the TOTAL FILING FEE and any additional fee due, and credit any overpayment, to Deposit Account No. 15-0750, Order No. OT-4190B. A duplicate copy hereof is enclosed.
4. [x] Cancel claims 1-43 and 58-65.
5. [x] On page 1, between lines 2 and 3, insert: --This is a division of copending application Serial No. 09/031,108 filed on February 26, 1998, the contents of which is incorporated herein by reference.--
6. [x] New drawings are enclosed: [ ] bristol board [ x ] paper.
7. [x] The prior application is assigned to Otis Elevator Company; recorded June 12, 1998 Reel 9248 Frame(s) 0387.
8. [x] The power of attorney in the prior application is to Randy G. Henley No. 35,188.
  - a. [x] The power appears in the original papers.
  - b. [ ] A copy of the power is enclosed herewith.
9. [x] Please enter the enclosed preliminary amendment after according a filing date.

[X] Date of Deposit May 24, 2000

Label No.EJ159310084US

I hereby verify that this fee and the attached application, including any drawing referred to above, is being deposited with the U.S. Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Commissioner of Patents and Trademarks, Washington DC 20231, and this statement was made with the knowledge that willful false statements and the like so made are punishable by fine and/or imprisonment under 18 USC 1001 and may jeopardize the validity of the application or any patent issuing thereon.

Elizabeth A. Dudek

Person Mailing Paper

Otis Elevator Company

Ten Farm Springs

Farmington, Connecticut 06032

(860) 676-5742

Randy G. Henley

Attorney of Record in prior application

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: : Docket: OT-4190B  
Pedro S. Baranda, et al. : Date: May 24, 2000  
Div. Serial No.: : Group Art Unit:  
Prior Appln. S.N.: 9/031,108 : Prior Group Art Unit: 3652  
Div. Filed: May 24, 2000 : Prior Examiner: T. Tran  
Prior Appln. Filing Date:: February 26, 1998 :

Title: Tension Member for an Elevator

Director of Patents and Trademarks  
Washington, D.C. 20231  
BOX NEW DIV. APPLN.

Dear Sirs:

PRELIMINARY AMENDMENT

Please amend the above-identified application as follows:

IN THE SPECIFICATION

Page 1:

Between lines 2 and 3, insert--This is a division of copending application Serial No. 09/031/108 filed February 26, 1998, the contents of which is incorporated herein by reference.--

IN THE CLAIMS

Please cancel claims 1-43 and 58-65 and replace with the following claims:

--1. A sheave for an elevator system, the elevator system including one or more tension members, each tension member having a width  $w$ , a thickness  $t$  measured in the bending direction, and an engagement surface defined by the width dimension of the tension member, wherein the tension member has an aspect ratio, defined as the ratio of width  $w$  relative to

thickness  $t$ , of greater than one the traction sheave including a surface configured to receive the engagement surface of the tension member.

2. The sheave according to Claim 1, wherein the elevator system further includes a car and counterweight interconnected by the tension members, and wherein the surface of the sheave is a traction surface configured to receive the engagement surface such that traction between the sheave and tension member moves the car and counterweight.

3. A sheave according to Claim 2, wherein the traction surface is contoured to complement the engagement surface of the tension member such that traction between the sheave and tension member is enhanced.

4. The sheave according to Claim 1, wherein the traction surface is contoured to complement the engagement surface of the tension member to guide the tension member during engagement with the sheave.

5. The sheave according to Claim 1, wherein the surface includes a diameter  $D$ , and wherein the diameter  $D$  varies laterally to provide a guidance mechanism during engagement of the tension member and sheave.

6. The sheave according to Claim 1, wherein the traction sheave includes a pair of retaining rims on opposite sides of the sheave.

7. The sheave according to Claim 1, wherein the sheave includes a surface for each tension member, and further includes one or more dividers that separate the plurality of surfaces.

8. The sheave according to Claim 1, further including a guidance device disposed proximate to the surface, the guidance device engageable with the tension member to position the tension member for engagement with the surface.

9. The sheave according to Claim 8, wherein the guidance device includes a roller engageable in rolling contact with the tension member.
10. The sheave according to Claim 1, wherein the surface is formed from a non-metallic material.
11. The sheave according to Claim 10, wherein the surface is formed from polyurethane.
12. The sheave according to Claim 1, further including a sheave liner disposed about the sheave, wherein the sheave liner defines the surface.
13. The sheave according to Claim 1, wherein the surface is formed from a non-metallic coating bonded to the sheave.
14. The sheave according to Claim 1, wherein the sheave is formed from a non-metallic material, and wherein the non-metallic material defines the surface for engaging the engagement surface of the one or more tension members.--

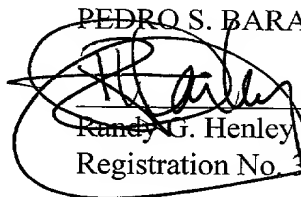
#### REMARKS

Applicant respectfully requests that the Examiner enter this amendment and pass claims 1-14 to issue.

Please charge any additional fees or credit overpayment to Deposit Account No. 15-0750, Order No. OT-4190B.

Respectfully submitted,

PEDRO S. BARANDA, ET AL.



Randy G. Henley  
Registration No. 35,188

Otis Elevator Company  
Otis Intellectual Property Dept.  
10 Farm Springs  
Farmington, CT 06032  
(860) 676-5742

## Description

### Tension Member for an Elevator

#### 5 Technical Field

The present invention relates to elevator systems, and more particularly to tension members for such elevator systems.

#### Background of the Invention

10 A conventional traction elevator system includes a car, a counterweight, two or more ropes interconnecting the car and counterweight, a traction sheave to move the ropes, and a machine to rotate the traction sheave. The ropes are formed from laid or twisted steel wire and the sheave is formed from cast iron. The machine may be either a geared or gearless machine. A geared machine  
15 permits the use of higher speed motor, which is more compact and less costly, but requires additional maintenance and space.

Although conventional steel ropes and cast iron sheaves have proven very reliable and cost effective, there are limitations on their use. One such limitation is the traction forces between the ropes and the sheave. These traction forces  
20 may be enhanced by increasing the wrap angle of the ropes or by undercutting the grooves in the sheave. Both techniques reduce the durability of the ropes, however, as a result of the increased wear (wrap angle) or the increased rope pressure (undercutting). Another method to increase the traction forces is to use liners formed from a synthetic material in the grooves of the sheave. The liners  
25 increase the coefficient of friction between the ropes and sheave while at the same time minimizing the wear of the ropes and sheave.

Another limitation on the use of steel ropes is the flexibility and fatigue characteristics of steel wire ropes. Elevator safety codes today require that each steel rope have a minimum diameter  $d$  ( $d_{\min}=8$  mm for CEN;  $d_{\min}=9.5$  mm (3/8"))

for ANSI) and that the  $D/d$  ratio for traction elevators be greater than or equal to forty ( $D/d \geq 40$ ), where  $D$  is the diameter of the sheave. This results in the diameter  $D$  for the sheave being at least 320 mm (380 mm for ANSI). The larger the sheave diameter  $D$ , the greater torque required from the machine to drive the elevator system.

With the development of high tensile strength, lightweight synthetic fibers has come the suggestion to replace steel wire ropes in elevator systems with ropes having load carrying strands formed from synthetic fibers, such as aramid fibers. Recent publications making this suggestion include: U.S. Patent No. 4,022,010, issued to Gladdenbeck et al.; U.S. Patent No. 4,624,097 issued to Wilcox; U.S. Patent No. 4,887,422 issued to Klees et al.; and U.S. Patent No. 5,566,786 issued to De Angelis et al. The cited benefits of replacing steel fibers with aramid fibers are the improved tensile strength to weight ratio and improved flexibility of the aramid materials, along with the possibility of enhanced traction between the synthetic material of the rope and the sheave.

Even ropes formed from aramid fiber strands, however, are subject to the limitations caused by the pressure on the ropes. For both steel and aramid ropes, the higher the rope pressure, the shorter the life of the rope. Rope pressure ( $P_{\text{rope}}$ ) is generated as the rope travels over the sheave and is directly proportional to the tension ( $F$ ) in the rope and inversely proportional to the sheave diameter  $D$  and the rope diameter  $d$  ( $P_{\text{rope}} \approx F/(Dd)$ ). In addition, the shape of the sheave grooves, including such traction enhancing techniques as undercutting the sheave grooves, further increases the maximum rope pressure to which the rope is subjected.

Even though the flexibility characteristic of such synthetic fiber ropes may be used to reduce the required  $D/d$  ratio, and thereby the sheave diameter  $D$ , the ropes will still be exposed to significant rope pressure. The inverse relationship between sheave diameter  $D$  and rope pressure limits the reduction in sheave diameter  $D$  that can be attained with conventional ropes formed from

aramid fibers. In addition, aramid fibers, although they have high tensile strength, are more susceptible to failure when subjected to transverse loads. Even with reductions in the D/d requirement, the resulting rope pressure may cause undue damage to the aramid fibers and reduce the durability of the ropes.

5           The above art notwithstanding, scientists and engineers under the direction of Applicants' Assignee are working to develop more efficient and durable methods and apparatus to drive elevator systems.

#### Disclosure of the Invention

10           According to the present invention, a tension member for an elevator has an aspect ratio of greater than one, where aspect ratio is defined as the ratio of tension member width  $w$  to thickness  $t$  (Aspect Ratio= $w/t$ ).

          A principal feature of the present invention is the flatness of the tension member. The increase in aspect ratio results in a tension member that has an  
15           engagement surface, defined by the width dimension, that is optimized to distribute the rope pressure. Therefore, the maximum pressure is minimized within the tension member. In addition, by increasing the aspect ratio relative to a round rope, which has an aspect ratio equal to one, the thickness of the tension member may be reduced while maintaining a constant cross-sectional area of the  
20           tension member.

          According further to the present invention, the tension member includes a plurality of individual load carrying ropes encased within a common layer of coating. The coating layer separates the individual ropes and defines an engagement surface for engaging a traction sheave.

25           As a result of the configuration of the tension member, the rope pressure may be distributed more uniformly throughout the tension member. As a result, the maximum rope pressure is significantly reduced as compared to a conventionally roped elevator having a similar load carrying capacity. Furthermore, the effective rope diameter 'd' (measured in the bending direction)

is reduced for the equivalent load bearing capacity. Therefore, smaller values for the sheave diameter 'D' may be attained without a reduction in the D/d ratio. In addition, minimizing the diameter D of the sheave permits the use of less costly, more compact, high speed motors as the drive machine without the need,for a gearbox.

In a particular embodiment of the present invention, the individual ropes are formed from strands of non-metallic material, such as aramid fibers. By incorporating ropes having the weight, strength, durability and, in particular, the flexibility characteristics of such materials into the tension member of the present invention, the acceptable traction sheave diameter may be further reduced while maintaining the maximum rope pressure within acceptable limits. As stated previously, smaller sheave diameters reduce the required torque of the machine driving the sheave and increase the rotational speed. Therefore, smaller and less costly machines may be used to drive the elevator system.

In a further particular embodiment of the present invention, a traction drive for an elevator system includes a tension member having an aspect ratio greater than one and a traction sheave having a traction surface configured to receive the tension member. The tension member includes an engagement surface defined by the width dimension of the tension member. The traction surface of the sheave and the engagement surface are complementarily contoured to provide traction and to guide the engagement between the tension member and the sheave. In an alternate configuration, the traction drive includes a plurality of tension members engaged with the sheave and the sheave includes a pair of rims disposed on opposite sides of the sheave and one or more dividers disposed between adjacent tension members. The pair of rims and dividers perform the function of guiding the engagement of the tension member with the sheave.

In another embodiment, the traction drive includes a guidance device disposed proximate to the traction sheave and engaged with the tension member. The guidance device positions the tension member for proper engagement with



the traction sheave. In a particular configuration, the guidance device includes a roller engaged with the tension member and/or the sheave to define a limited space for the tension member to engage the sheave.

5 In a still further embodiment, the traction surface of the sheave is defined by a material that optimizes the traction forces between the sheave and the tension member and minimizes the wear of the tension member. In one configuration, the traction surface is integral to a sheave liner that is disposed on the sheave. In another configuration, the traction surface is defined by a coating layer that is bonded to the traction sheave. In a still further configuration, the traction sheave is formed from the material that defines the traction surface.

10 Although described herein as primarily a traction device for use in an elevator application having a traction sheave, the tension member may be useful and have benefits in elevator applications that do not use a traction sheave to drive the tension member, such as indirectly roped elevator systems, linear motor driven elevator systems, or self-propelled elevators having a counterweight. In these applications, the reduced size of the sheave may be useful in order to reduce space requirements for the elevator system. The foregoing and other objects, features and advantages of the present invention become more apparent in light of the following detailed description of the exemplary embodiments thereof, as illustrated in the accompanying drawings.

#### Brief Description of the Drawings

Figure 1 is perspective view of an elevator system having a traction drive according to the present invention.

25 Figure 2 is a sectional, side view of the traction drive, showing a tension member and a sheave.

Figure 3 is a sectional, side view of an alternate embodiment showing a plurality of tension members and a roller guide assembly.

Figure 4 is another alternate embodiment showing a traction sheave having an hour glass shape to center the tension member.

Figure 5 is a further alternate embodiment showing a traction sheave and tension member having complementary contours to enhance traction and to guide the engagement between the tension member and the sheave.

Figure 6a is a sectional view of the tension member; Figure 6b is a sectional view of an alternate embodiment of a tension member; Figure 6c is a sectional view of a further alternate embodiment of a tension member; and Figure 6d is a sectional view of a still further embodiment of a tension member.

#### Best Mode for Carrying Out the Invention

Illustrated in Figure 1 is a traction elevator system 12. The elevator system 12 includes a car 14, a counterweight 16, a traction drive 18, and a machine 20. The traction drive 18 includes a tension member 22, interconnecting the car 14 and counterweight 16, and a traction sheave 24. The tension member 22 is engaged with the sheave 24 such that rotation of the sheave 24 moves the tension member 22, and thereby the car 14 and counterweight 16. The machine 20 is engaged with the sheave 24 to rotate the sheave 24. Although shown as an geared machine 20, it should be noted that this configuration is for illustrative purposes only, and the present invention may be used with geared or gearless machines.

The tension member 22 and sheave 24 are illustrated in more detail in Figure 2. The tension member 22 is a single device that integrates a plurality of ropes 26 within a common coating layer 28. Each of the ropes 26 is formed from laid or twisted strands of high strength synthetic, non-metallic fibers, such as commercially available aramid fibers. The ropes 26 are equal length, are spaced widthwise within the coating layer 28 and are arranged linearly along the width dimension. The coating layer 28 is formed from a polyurethane material that is extruded onto the plurality of ropes 26 in such a manner that each of the

individual ropes 26 is retained against longitudinal movement relative to the other ropes 26. Other materials may also be used for the coating layer 28 if they are sufficient to meet the required functions of the coating layer: traction, wear, transmission of traction loads to the ropes 26 and resistance to environmental factors. The coating layer 28 defines an engagement surface 30 that is in contact with a corresponding surface of the traction sheave 24.

As shown more clearly in Figure 6a, the tension member 22 has a width  $w$ , measured laterally relative to the length of the tension member 22, and a thickness  $t_1$ , measured in the direction of bending of the tension member 22 about the sheave 24. Each of the ropes 26 has a diameter  $d$  and are spaced apart by a distance  $s$ . In addition, the thickness of the coating layer 28 between the ropes 26 and the engagement surface 30 is defined as  $t_2$  and between the ropes 26 and the opposite surface is defined as  $t_3$ , such that  $t_1 = t_2 + t_3 + d$ .

The overall dimensions of the tension member 22 results in a cross-section having an aspect ratio of much greater than one, where aspect ratio is defined as the ratio of width  $w$  to thickness  $t_1$  or (Aspect Ratio =  $w/t_1$ ). An aspect ratio of one corresponds to a circular cross-section, such as that common in conventional round ropes 26. The higher the aspect ratio, the more flat the tension member 22 is in cross-section. Flattening out the tension member 22 minimizes the thickness  $t_1$  and maximizes the width  $w$  of the tension member 22 without sacrificing cross-sectional area or load carrying capacity. This configuration results in distributing the rope pressure across the width of the tension member 22 and reduces the maximum rope pressure relative to a round rope of comparable cross-sectional area. As shown in Figure 1, for the tension member 22 having five individual round ropes 26 disposed within the coating layer 28, the aspect ratio is greater than five. Although shown as having an aspect ratio greater than five, it is believed that benefits will result from tension members having aspect ratios greater than one, and particularly for aspect ratios greater than two.

The separation  $s$  between adjacent ropes 26 is dependant upon the weight of the materials used in the tension member 22 and the distribution of rope stress across the tension member 22. For weight considerations, it is desirable to minimize the spacing  $s$  between adjacent ropes 26, thereby reducing the amount of coating material between the ropes 26. Taking into account rope stress distribution, however, may limit how close the ropes 26 may be to each other in order to avoid excessive stress in the coating layer 28 between adjacent ropes 26. Based on these considerations, the spacing may be optimized for the particular load carrying requirements.

The thickness  $t_2$  of the coating layer 28 is dependant upon the rope stress distribution and the wear characteristics of the coating layer 28 material. As before, it is desirable to avoid excessive stress in the coating layer 28 while providing sufficient material to maximize the expected life of the tension member 22.

The thickness  $t_3$  of the coating layer 28 is dependant upon the use of the tension member 22. As illustrated in Figure 1, the tension member 22 travels over a single sheave 24 and therefore the top surface 32 does not engage the sheave 24. In this application, the thickness  $t_3$  may be very thin, although it must be sufficient to withstand the strain as the tension member 22 travels over the sheave 24. On the other hand, a thickness  $t_3$  equivalent to that of  $t_2$  may be required if the tension member 22 is used in an elevator system that requires reverse bending of the tension member 22 about a second sheave. In this application, both the upper 32 and lower surface 30 of the tension member 22 is an engagement surface and subject to the same requirement of wear and stress.

The diameter  $d$  of the individual ropes 26 and the number of ropes 26 is dependant upon the specific application. It is desirable to maintain the thickness  $d$  as small as possible in order to maximize the flexibility and minimize the stress in the ropes 26. The actual diameter  $d$  will depend on the load required to be

carried by the tension member 22 and the space available, widthwise, for the tension member 22.

Although illustrated in Figure 2 as having a plurality of round ropes 26 embedded within the coating layer 28, other styles of individual ropes may be used with the tension member 22, including those that have aspect ratios greater than one, for reasons of cost, durability or ease of fabrication. Examples include oval shaped ropes 34 (Figure 6b), flat or rectangular shaped ropes 36 (Figure 6c), or a single flat rope 38 distributed through the width of the tension member 22 as shown in Figure 6d. An advantage of the embodiment of Figure 6d is that the distribution of rope pressure may be more uniform and therefore the maximum rope pressure within the tension member 22 may be less than in the other configurations. Since the ropes are encapsulated within a coating layer, and since the coating layer defines the engagement surface, the actual shape of the ropes is less significant for traction and may be optimized for other purposes.

Referring back to Figure 2, the traction sheave 24 includes a base 40 and a liner 42. The base 40 is formed from cast iron and includes a pair of rims 44 disposed on opposite sides of the sheave 24 to form a groove 46. The liner 42 includes a base 48 having a traction surface 50 and a pair of flanges 52 that are supported by the rims 44 of the sheave 24. The liner 42 is formed from a polyurethane material, such as that described in commonly owned US Patent No. 5,112,933. or any other suitable material providing the desired traction with the engagement surface 30 of the coating layer 28 and wear characteristics. Within the traction drive 18, it is desired that the sheave liner 42 wear rather than the sheave 24 or the tension member 22 due to the cost associated with replacing the tension member 22 or sheave 24. As such, the liner 42 performs the function of a sacrificial layer in the traction drive 18. The liner 42 is retained, either by bonding or any other conventional method, within the groove 46 and defines the traction surface 50 for receiving the tension member 22. The traction surface 50

has a diameter D. Engagement between the traction surface 50 and the engagement surface 30 provides the traction for driving the elevator system 12.

Although illustrated as having a liner 42, it should be apparent to those skilled in the art that the tension member 22 may be used with a sheave not having a liner 42. As an alternative, the liner 42 may be replaced by coating the sheave with a layer of a selected material, such as polyurethane, or the sheave may be formed or molded from an appropriate synthetic material. These alternatives may prove cost effective if it is determined that, due to the diminished size of the sheave, it may be less expensive to simply replace the entire sheave rather than replacing sheave liners.

The shape of the sheave 24 and liner 42 defines a space 54 into which the tension member 22 is received. The rims 44 and the flanges 52 of the liner 42 provide a boundary on the engagement between the tension member 22 and the sheave 24 and guide the engagement to avoid the tension member 22 becoming disengaged from the sheave 24.

An alternate embodiment of the traction drive 18 is illustrated in Figure 3. In this embodiment, the traction drive 18 includes three tension members 56, a traction sheave 58, and a guidance mechanism 60. Each of the tension members 56 is similar in configuration to the tension member 22 described above with respect to Figures 1 and 2. The traction sheave 58 includes a base 62, a pair of rims 64 disposed on opposite side of the sheave 58, a pair of dividers 66, and three liners 68. The dividers 66 are laterally spaced from the rims 64 and from each other to define three grooves 70 that receive the liners 68. As with the liner 42 described with respect to Figure 2, each liner 68 includes a base 72 that defines a traction surface 74 to receive one of the tension members 56 and a pair of flanges 76 that abut the rims 64 or dividers 66.

The guidance mechanism 60 is located on both sides of the sheave 58 and proximate to the take-up and take-off points for the tension member 56. The guidance mechanism 60 includes a frame 78, a pair of bearings 80, a shaft 82,

and three rollers 84. The bearings 80 permit rotation of the shaft 82 and rollers 84. The rollers 84 are spaced apart such that each roller 84 is proximate to one of the grooves 70 of the sheave 58 in the region of contact with the corresponding tension member 56. The arrangement of the roller 84 and the groove 70, and liner 68 results in a limited space for the tension member 56. The space restriction guides the tension member 56 during engagement and ensures that the tension member 56 remains aligned with the traction surface 74 of the liner 68.

Alternative guidance mechanisms for the traction drive 18 are illustrated in Figures 4 and 5. Figure 4 illustrates a sheave 86 having an hour glass shaped traction surface 88. The shape of the traction surface 88 urges the flat tension member 90 to remain centered during operation. Figure 5 illustrates a tension member 92 having a contoured engagement surface 94 that is defined by the encapsulated ropes 96. The traction sheave 98 includes a liner 100 that has a traction surface 102 that is contoured to complement the contour of the tension member 92. The complementary configuration provides guidance to the tension member 92 during engagement and, in addition, increases the traction forces between the tension member 92 and the traction sheave 98.

Use of tension members and traction drives according to the present invention may result in significant reductions in maximum rope pressure, with corresponding reductions in sheave diameter and torque requirements. The reduction in maximum rope pressure results from the cross-sectional area of the tension member having an aspect ratio of greater than one. For this configuration, assuming that the tension member is such as that shown in Figure 6d, the calculation for maximum rope pressure is determined as follows:

$$P_{\max} \equiv (2F/Dw)$$

Where F is the maximum tension in the tension member. For the other configurations of Figure 6a-c, the maximum rope pressure would be approximately the same although slightly higher due to the discreteness of the

individual ropes. For a round rope within a round groove, the calculation of maximum rope pressure is determined as follows:

$$P_{\max} \equiv (2F/Dd)(4/\pi)$$

5 The factor of  $(4/\pi)$  results in an increase of at least 27% in maximum rope pressure, assuming that the diameters and tension levels are comparable. More significantly, the width  $w$  is much larger than the rope diameter  $d$ , which results in greatly reduced maximum rope pressure. If the conventional rope grooves are undercut, the maximum rope pressure is even greater and therefore greater relative reductions in the maximum rope pressure may be achieved. Another  
10 advantage of the tension member according to the present invention is that the thickness  $t_1$  of the tension member may be much smaller than the diameter  $d$  of equivalent load carrying capacity round ropes. This enhances the flexibility of the tension member as compared to conventional ropes.

For instance, for a sheave typical low rise gearless elevator system, the  
15 use of three tension members, each with five 3mm aramid fiber ropes, may result in reductions in approximately fifty percent in maximum rope pressure and eighty percent in rated torque, peak torque and sheave diameter as compared to conventional steel ropes (four 10mm SISAL core steel wire ropes) and reductions of approximately sixty percent in rated torque, peak torque and sheave diameter  
20 as compared to conventional round ropes formed from comparable aramid fibers (three 8mm aramid fiber ropes).

Although the invention has been shown and described with respect to exemplary embodiments thereof, it should be understood by those skilled in the art that various changes, omissions, and additions may be made thereto, without  
25 departing from the spirit and scope of the invention.



## Claims

What is claimed is:

- 5        1.        A tension member for providing lifting force to an car of an elevator system, the tension member being engageable with a rotatable sheave of the elevator system, the tension member having a width  $w$ , a thickness  $t$  measured in the bending direction, and an engagement surface defined by the width dimension of the tension member, wherein the tension member has an aspect  
10        ratio, defined as the ratio of width  $w$  relative to thickness  $t$ , greater than one.
- 15        2.        The tension member according to Claim 1, further including a plurality of individual load carrying ropes encased within a common layer of coating, the coating layer separating the individual ropes, wherein the coating layer defines  
15        the engagement surface for engaging the sheave.
- 20        3.        The tension member according to Claim 2, wherein the individual ropes are formed from strands of non-metallic material.
- 20        4.        The tension member according to Claim 1, wherein the tension member is formed from strands of non-metallic material.
- 25        5.        The tension member according to Claim 2, wherein the coating layer blocks differential longitudinal motion of the plurality of individual ropes.
- 25        6.        The tension member according to Claim 5, wherein the coating layer retains each of the ropes to block the occurrence of differential motion.

7. The tension member according to Claim 1, wherein the aspect ratio is greater than or equal to two.
8. The tension member according to Claim 2, wherein the individual ropes are spaced widthwise within the common coating layer.
9. The tension member according to Claim 2, wherein the coating layer defines a single engagement surface for the plurality of individual ropes.
10. The tension member according to Claim 9, wherein the coating layer extends widthwise such that the engagement surface extends about the plurality of individual ropes.
11. The tension member according to Claim 1, wherein the sheave includes an engagement surface, and wherein the engagement surface of the tension member is contoured to complement the engagement surface of the sheave.
12. The tension member according to Claim 2, wherein the engagement surface of the coating layer is shaped by the outer surface of the ropes to enhance the traction between the traction sheave and the traction member.
13. The tension member according to Claim 1, further including a coating layer formed from an elastomer.
14. The tension member according to Claim 2, wherein the coating layer is formed from an elastomer.

15. The tension member according to Claim 2, wherein the maximum rope pressure of the load carrying ropes is approximately defined by the following equation:

5 
$$P_{\max} = (2F/Dw)$$

Where F is the maximum tension in the tension member and D is the diameter of the traction sheave.

10 16. The tension member according to Claim 1, wherein the engagement surface is shaped to guide the tension member during engagement with the sheave.

15 17. The tension member according to Claim 2, wherein the engagement surface of the coating layer is shaped by the outer surface of the ropes to guide the tension member during engagement with the sheave.

20 18. The tension member according to Claim 2, wherein the plurality of individual ropes are arranged linearly.

19. The tension member according to Claim 8, wherein the plurality of individual ropes are arranged linearly.

25 20. The tension member according to Claim 2, wherein the individual ropes are round in cross-section.

21. The tension member according to Claim 2, wherein the individual ropes have an aspect ratio greater than one.

22. The tension member according to Claim 2, wherein the individual ropes are flat in cross-section.

23. A traction drive for an elevator system, the elevator system including a car and a counterweight, the traction drive including a traction sheave driven by a machine and a tension member interconnecting the car and counterweight, the tension member having a width  $w$ , a thickness  $t$  measured in the bending direction, and an engagement surface defined by the width dimension of the tension member, wherein the tension member has an aspect ratio, defined as the ratio of width  $w$  relative to thickness  $t$ , of greater than one, the traction sheave including a traction surface configured to receive the engagement surface of the tension member such that the traction between the sheave and tension member moves the car and counterweight.

24. The traction drive according to Claim 23, wherein the tension member further includes a plurality of individual load carrying ropes encased within a common layer of coating, the coating layer separating the individual ropes and defining the engagement surface for the tension member.

25. The traction drive according to Claim 23, wherein the traction surface is contoured to complement the engagement surface of the tension member such that traction between the traction sheave and tension member is enhanced.

26. The traction drive according to Claim 23, wherein the traction surface is contoured to complement the engagement surface of the tension member to guide the tension member during engagement with the traction sheave.

27. The traction drive according to Claim 23, wherein the traction surface includes a diameter D, and wherein the diameter D varies laterally to provide a guidance mechanism during engagement of the tension member and traction sheave.

5

28. The traction drive according to Claim 23, wherein the traction sheave includes a pair of retaining rims on opposite sides of the traction sheave.

29. The traction drive according to Claim 23, including a plurality of the  
10 tension members.

30. The traction drive according to Claim 29, wherein the traction sheave includes a traction surface for each tension member, and further includes one or more dividers that separate the plurality of traction surfaces.

15

31. The traction drive according to Claim 23, further including a guidance device disposed proximate to the traction sheave, the guidance device engaged with the tension member to position the tension member for engagement with the traction sheave.

20

32. The traction drive according to Claim 31, wherein the guidance device includes a roller engaged in rolling contact with the tension member.

33. The traction drive according to Claim 23, wherein the traction surface is  
25 formed from a non-metallic material.

34. The traction drive according to Claim 28, wherein the tension member is formed from a non-metallic material.

35. The traction drive according to Claim 24, wherein the ropes are formed from non-metallic material.

5 36. The traction drive according to Claim 24, wherein the coating layer is formed from elastomer.

37. The traction drive according to Claim 23, wherein the tension member further includes a coating layer that defines the engagement surface, and wherein the coating layer is formed from elastomer.

10

38. The traction drive according to Claim 33, wherein the traction surface is formed from polyurethane.

15 39. The traction drive according to Claim 23, wherein the maximum rope pressure of the load carrying ropes is approximately defined by the following equation:

$$P_{\max} = (2F/Dw)$$

20 Where F is the tension in the tension member and D is the diameter of the traction sheave.

40. The traction drive according to Claim 23, further including a sheave liner disposed about the traction sheave, wherein the sheave liner defines the traction surface.

25

41. The traction drive according to Claim 23, wherein the traction surface is defined by a coating layer that is bonded to the traction sheave.

42. The traction drive according to Claim 23, wherein the traction sheave is formed from the material defining the traction surface.

5 43. The traction drive according to Claim 42, wherein the traction sheave is formed from polyurethane.

10 44. A sheave for an elevator system, the elevator system including one or more tension members, each tension member having a width  $w$ , a thickness  $t$  measured in the bending direction, and an engagement surface defined by the width dimension of the tension member, wherein the tension member has an aspect ratio, defined as the ratio of width  $w$  relative to thickness  $t$ , of greater than one the traction sheave including a surface configured to receive the engagement surface of the tension member.

15 45. The sheave according to Claim 44, wherein the elevator system further includes a car and counterweight interconnected by the tension members, and wherein the surface of the sheave is a traction surface configured to receive the engagement surface such that traction between the sheave and tension member moves the car and counterweight.

20 46. A sheave according to Claim 45, wherein the traction surface is contoured to complement the engagement surface of the tension member such that traction between the sheave and tension member is enhanced.

25 47. The sheave according to Claim 44, wherein the traction surface is contoured to complement the engagement surface of the tension member to guide the tension member during engagement with the sheave.

48. The sheave according to Claim 44, wherein the surface includes a diameter D, and wherein the diameter D varies laterally to provide a guidance mechanism during engagement of the tension member and sheave.

5 49. The sheave according to Claim 44, wherein the traction sheave includes a pair of retaining rims on opposite sides of the sheave.

50. The sheave according to Claim 44, wherein the sheave includes a surface for each tension member, and further includes one or more dividers that separate  
10 the plurality of surfaces.

51. The sheave according to Claim 44, further including a guidance device disposed proximate to the surface, the guidance device engageable with the tension member to position the tension member for engagement with the surface.  
15

52. The sheave according to Claim 51, wherein the guidance device includes a roller engageable in rolling contact with the tension member.

53. The sheave according to Claim 44, wherein the surface is formed from a non-metallic material.  
20

54. The sheave according to Claim 53, wherein the surface is formed from polyurethane.

25 55. The sheave according to Claim 44, further including a sheave liner disposed about the sheave, wherein the sheave liner defines the surface.

56. The sheave according to Claim 44, wherein the surface is formed from a non-metallic coating bonded to the sheave.



57. The sheave according to Claim 44, wherein the sheave is formed from a non-metallic material, and wherein the non-metallic material defines the surface for engaging the engagement surface of the one or more tension members.

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58. A liner for a sheave of an elevator system, the elevator system including one or more tension members, each tension member having a width  $w$ , a thickness  $t$  measured in the bending direction, and an engagement surface defined by the width dimension of the tension member, wherein the tension member has an aspect ratio, defined as the ratio of width  $w$  relative to thickness  $t$ , of greater than one, the liner disposed in a fixed relationship to the sheave and including a surface configured to receive the engagement surface of the tension member.

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59. The liner according to Claim 58, wherein the elevator system further includes a car and counterweight interconnected by the tension members, and wherein the surface of the liner is a traction surface configured to receive the engagement surface such that traction between the liner and tension member moves the car and counterweight.

20

60. The liner according to Claim 59, wherein the surface is contoured to complement the engagement surface of the tension member such that traction between the liner and tension member is enhanced.

25

61. The liner according to Claim 58, wherein the surface is contoured to complement the engagement surface of the tension member to guide the tension member during engagement with the liner.

62. The liner according to Claim 58, wherein the surface includes a diameter D, and wherein the diameter D varies laterally to provide a guidance mechanism during engagement of the tension member and liner.

5 63. The liner according to Claim 58, wherein the liner is formed from a non-metallic material.

64. The liner according to Claim 63, wherein the liner is formed from polyurethane.

10

65. The liner according to Claim 58, wherein the elevator system includes a plurality of tension members, and wherein the liner extends laterally to accommodate the plurality of tension members.

## Abstract

### Tension Member for an Elevator

5           A tension member for an elevator system has an aspect ratio of greater  
than one, where aspect ratio is defined as the ratio of tension member width  $w$  to  
thickness  $t$  ( $w/t$ ). The increase in aspect ratio results in a reduction in the  
maximum rope pressure and an increased flexibility as compared to conventional  
elevator ropes. As a result, smaller sheaves may be used with this type of tension  
10 member. In a particular embodiment, the tension member includes a plurality of  
individual load carrying ropes encased within a common layer of coating. The  
coating layer separates the individual ropes and defines an engagement surface  
for engaging a traction sheave.

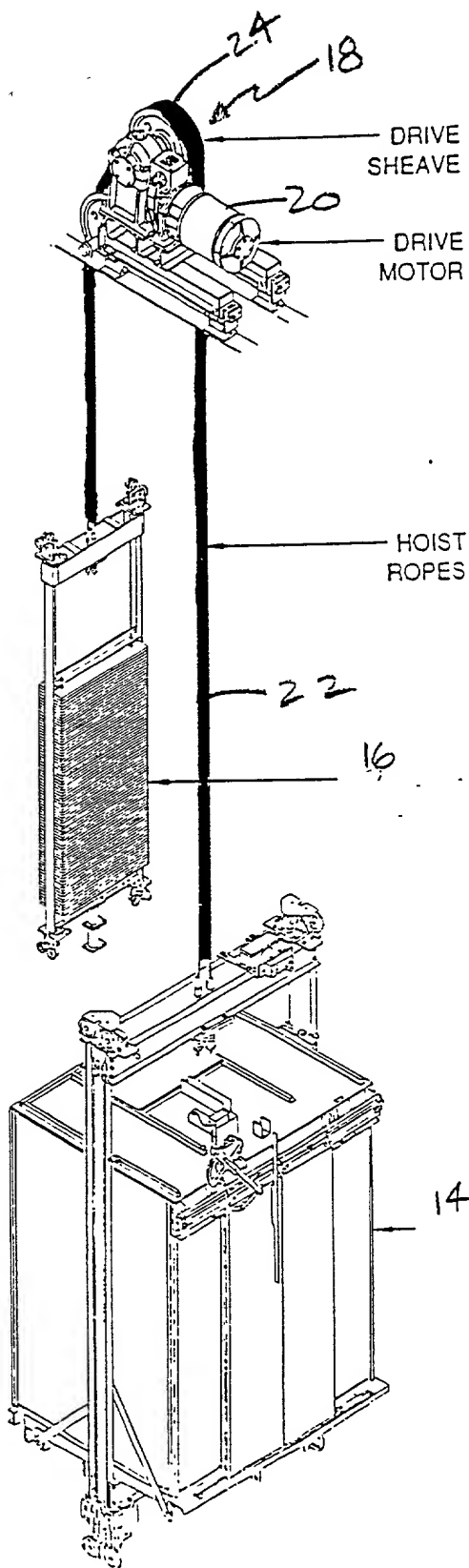
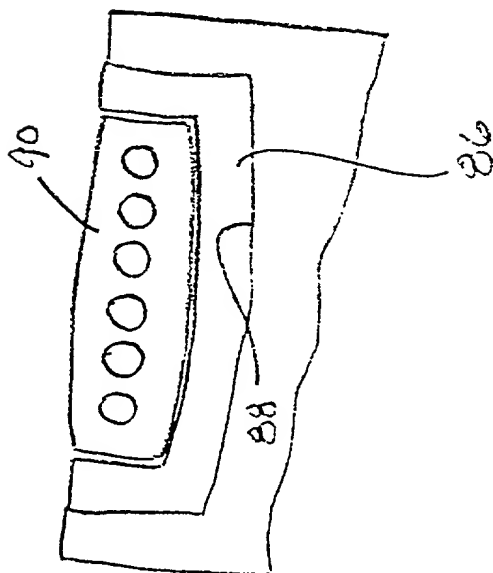
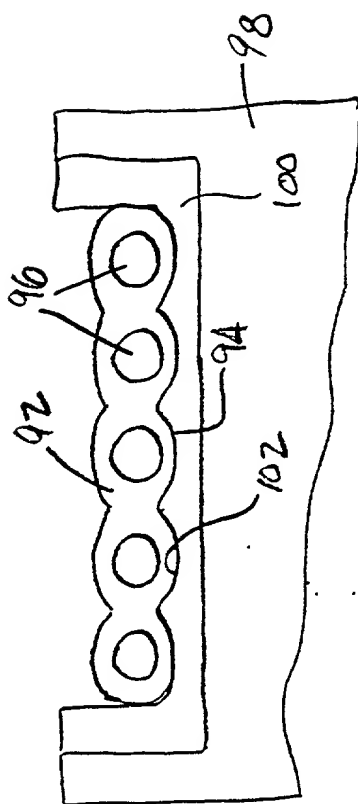
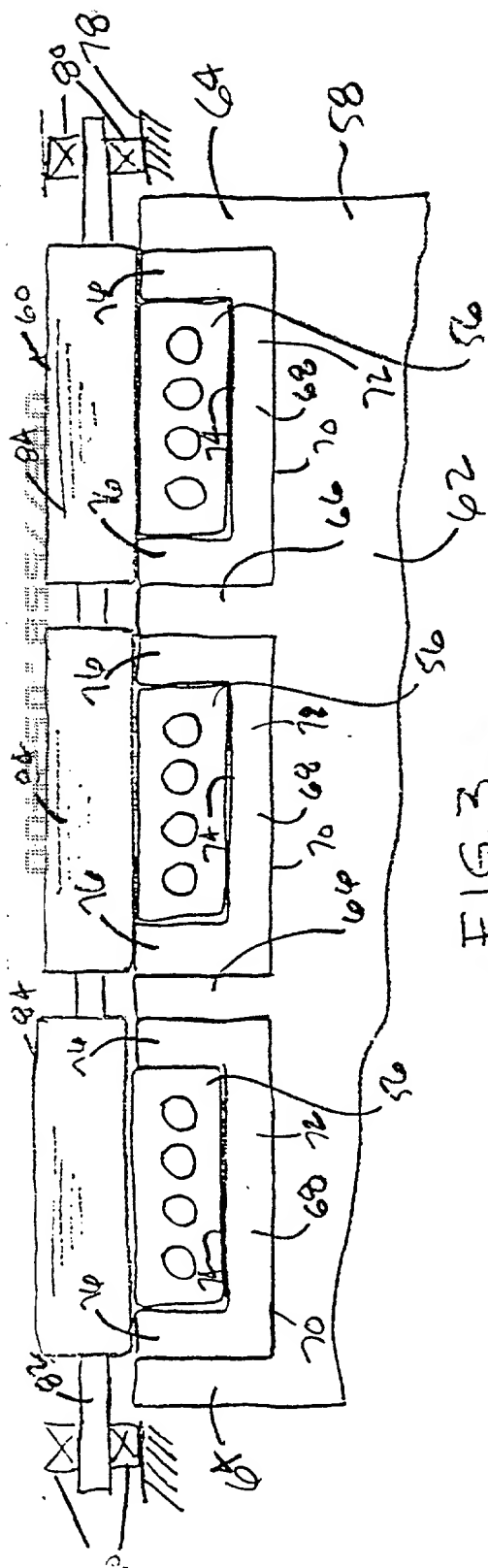


FIG. 1





COMBINED DECLARATION AND POWER OF  
ATTORNEY IN ORIGINAL APPLICATIONDOCKET NO.  
OT-4190

I declare: that my residence and citizenship is as stated below next to my name; that I believe I am the original, first and sole inventor (if only I am named below) or joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought in the application assigned Serial No. \_\_\_\_\_, filed February 26, 1998 entitled

**TENSION MEMBER FOR AN ELEVATOR**

that I have reviewed and I understand the contents of the above-identified specification, including the claims; that I acknowledge the duty to disclose to the Patent and Trademark Office all information known to me to be material to patentability as defined in 37 C.F.R. §1.56; that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

I appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

Robert P. Hayter (Reg. No. 28,424); Troxell K. Snyder (Reg. No. 30,804); Randy G. Henley (Reg. No. 35,188)

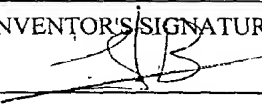
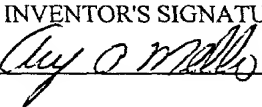
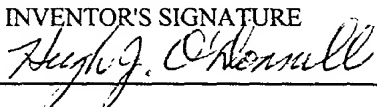
Direct all correspondence to:

Telephone:

**Randy G. Henley**

(860) 676-5742

Otis Elevator Company  
Intellectual Property Department  
10 Farm Springs  
Farmington, CT 06032

FULL NAME OF SOLE OR 1ST INVENTOR <b>Pedro S. Baranda</b>	INVENTOR'S SIGNATURE 	DATE <b>2/26/98</b>
RESIDENCE AND POST OFFICE ADDRESS  52 Berkshire Drive, Farmington, Connecticut 06032		CITIZENSHIP  Spanish
FULL NAME OF 2ND JOINT INVENTOR <b>Ary O. Mello</b>	INVENTOR'S SIGNATURE 	DATE <b>2/26/98</b>
RESIDENCE AND POST OFFICE ADDRESS  6 Penfield Place, Farmington, Connecticut 06032		CITIZENSHIP  U.S.
FULL NAME OF 3RD JOINT INVENTOR <b>Hugh J. O'Donnell</b>	INVENTOR'S SIGNATURE 	DATE <b>2/26/98</b>
RESIDENCE AND POST OFFICE ADDRESS  289 Converse Street, Longmeadow, Massachusetts 01106		CITIZENSHIP  U.S.

FULL NAME OF 4TH JOINT INVENTOR	INVENTOR'S SIGNATURE	DATE
Karl M. Prewo	<i>Karl M. Prewo</i>	2/24/98
RESIDENCE AND POST OFFICE ADDRESS		CITIZENSHIP
63 Indian Trail, Vernon, Connecticut 06066		U.S.A.
FULL NAME OF 5TH JOINT INVENTOR	INVENTOR'S SIGNATURE	DATE
RESIDENCE AND POST OFFICE ADDRESS		CITIZENSHIP
FULL NAME OF 6TH JOINT INVENTOR	INVENTOR'S SIGNATURE	DATE
RESIDENCE AND POST OFFICE ADDRESS		CITIZENSHIP
FULL NAME OF 7TH JOINT INVENTOR	INVENTOR'S SIGNATURE	DATE
RESIDENCE AND POST OFFICE ADDRESS		CITIZENSHIP